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Typhoon frequency and intensity across the Western Pacific Ocean north of the Equator, 1951 – 2014

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Abstract: Disturbance has been a repeated theme in ecology in recent decades, yet incorporating its frequency and pattern at broad spatial scales into ecological analyses has been difficult – rather, most environmental datasets used in broad-extent analyses represent average conditions. We present a detailed dataset summarizing the frequency (i.e., number of typhoons) and intensity (average and maximum windspeeds) of typhoons across the Western Pacific north of the Equator, based on data characterizing tracks for 1673 typhoons from the Japan Meteorological Center. The data presented are aggregated and resampled to 0.2° (~22 km at the Equator) spatial resolution; temporal coverage extends 1951 – 2014. We also present data specifically for prior to 1980 and after 1999, to respond to questions related to climate change, although no major changes were evident between the time periods.

Keywords: typhoon; disturbance; Western Pacific; maps

Dataset Profile

English title	Typhoon frequency and intensity across the Western Pacific Ocean north of the Equator, 1951 – 2014		
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Data authors	A. Townsend Peterson, Lindsay P. Campbell, Rafe M. Brown		
Time range	1951 – 2014		
Geographical scope	0° – 90°N latitude, 90°E – 160°W longitude; Western Pacific Ocean north of the Equator and adjoining land areas		
Spatial resolution	0.2° (~22 km at the Equator)	**Data volume**	1673 typhoon tracks
Data format	1 line shapefile, 3 GeoTIFF raster data files		
Data service system	Science DB, <http://www.sciencedb.cn/dataSet/handle/396>; KU Scholarworks, <http://hdl.handle.net/1808/22466>		
Source of funding	U.S. National Science Foundation, grant number DEB-1418895		

Dataset composition	See summary of datasets and their characteristics in Table 1. For each data dimension, as feasible, we provide data subsets for the entire time span of the data, prior to 1980, and after 2000; the latter two time periods relate to before the onset of major global climate change, and after such changes had been ongoing for two decades. **TyphoonTracks.zip**: Line shapefile summarizing 1673 typhoon tracks across the Western Pacific north of the Equator. Fields in attributes table: • TyphoonID: A unique code corresponding to each of the typhoons analyzed in the dataset from the Japan Meteorological Center • ID: A code unique to each TyphoonID that provides specific data for the typhoon at a point in time • ymd: Year, month, day corresponding to the particular PositionID of the typhoon in question • Grade: The severity grade rating associated with the typhoon at that particular point in time • Windspeed: Windspeed measured for the typhoon at that particular point in time **Typhoons_avgwind.zip**: GeoTIFF raster file summarizing the average value of windspeed for typhoons crossing the pixel in the timespan specified (_all = 1977 – 2014, _2000 = 2000 – 2014) **Typhoons_maxwind.zip**: GeoTIFF raster file summarizing the maximum value of windspeed for typhoons crossing the pixel in the timespan specified (_all = 1977 – 2014, _2000 = 2000 – 2014) **Typhoons_count.zip**: GeoTIFF raster file summarizing the number of typhoons crossing the pixel in the timespan specified (_all = 1951 – 2014, _1980 = 1951 – 1979, _2000 = 2000 – 2014)

1. Introduction

Disturbance has become the focus of intense interest in ecology,[1–6] as part of a shift from focus on average conditions to a fuller appreciation of the dynamics of natural systems. Disturbance also – almost by definition – implies longer time scales, with different disturbance regimes associated with different time spans.[7] This new focus on extreme events on longer time scales becomes still more relevant in view of outputs of general circulation models that indicate that future climates may be characterized by more extreme and frequent extreme events.[8]

An important, large-scale agent of disturbance in many marine and coastal systems are typhoons and hurricanes,[9] many of which cross the world's oceans each year. Even though typhoon-disturbance-adaptation is well-documented in many ecosystems,[10, 11] incorporation of these unpredictable and episodic events into broader-scale, regional analyses and analyses of geographic distributions of species has been minimal or lacking. As such, here, we present datasets synthesizing typhoon frequency and intensity across the Western Pacific north of the Equator, based on a dataset that spans 63 years.

This dataset is rather unusual in that it summarizes large-scale disturbance frequency and intensity on a near-hemispheric scale. We are intrigued with region-to-region differences in typhoon-mediated disturbance, beyond the well-known tropical and subtropical concentration of these storms. That is, for example, we note strong contrasts between the central and northern Philippines *versus* the southern Philippines in terms of typhoon frequency. The striking contrast in typhoon frequency across such a relatively restricted set of latitudes has important implications in terms of forest dynamics, dispersal opportunities, and extinction probabilities for species. We failed to detect clear temporal trends in typhoon characteristics that might relate to climate change processes occurring globally.

2. Data acquisition and processing

2.1 Overview

This dataset summarizes the frequency (i.e., number) and intensity of typhoons (average and maximum windspeeds) across the Western Pacific north of the Equator. The data are summarized from individual typhoon track data from the Japan Meteorological Center, over the period 1951 – 2014, via a simple interpolation procedure (Figure 1). That is, the raw data are presented as a day-by-day series of points with information on typhoon strength; we extended daily values to the midpoints of connecting line segments to create continuous tracks with day-specific strength information for each typhoon (Figure 2). Finally, typhoon track data were processed into raster-format summaries of typhoon frequencies and strengths across the Western Pacific north of the Equator and adjacent landmasses (Figure 3).

Our data products were limited by the daily temporal resolution of the available data: that is, a fast-moving typhoon will have coarser spatial resolution than a slow-moving typhoon. World Meteorological Organization classifications were not explored, which permitted us to focus on quantitative aspects of typhoons in the region. Data are presented for the entire time span, as well as for prior to

1980 and after 1999 (Table 1), to respond to questions related to climate change (Figure 4).

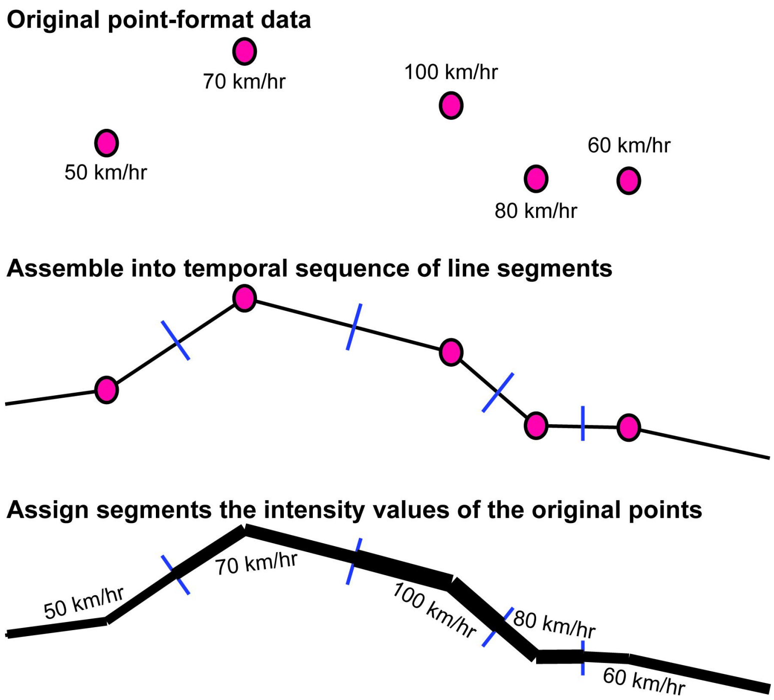

Figure 1 Summary of process by which point-format original data were transformed into continuous, line-format shapefiles

Notes: The blue hash-marks represent the midpoints (spatially) between each consecutive pair of points. Each line segment, from hash-mark to hash-mark, represents a separate entity in the shapefile, with distinct attributes (e.g., windspeed).

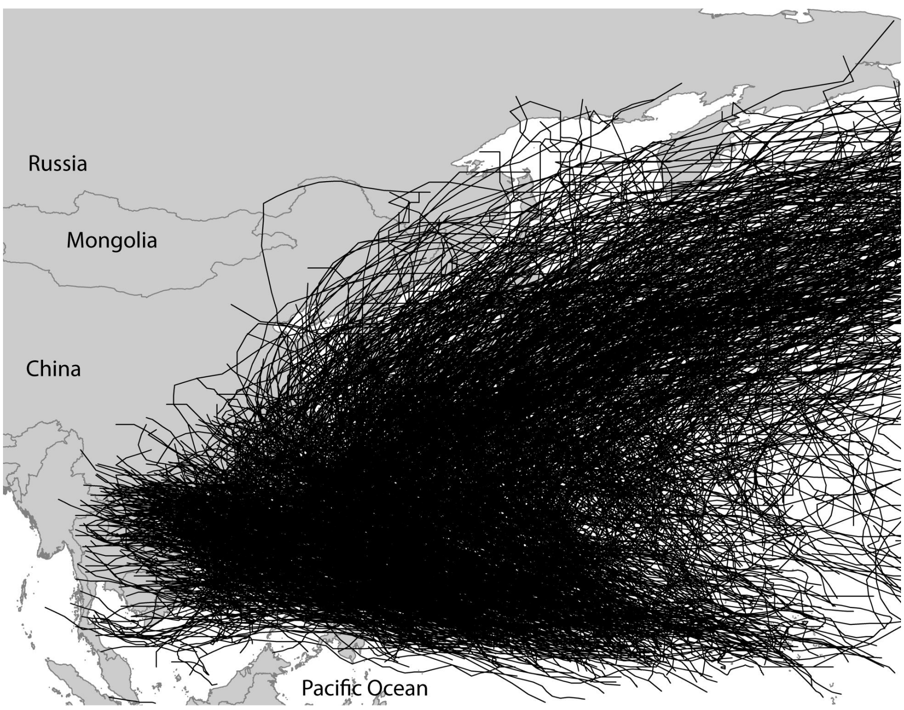

Figure 2 Visualization of individual typhoon tracks in the Western Pacific Ocean north of the Equator over the period 1951 – 2014

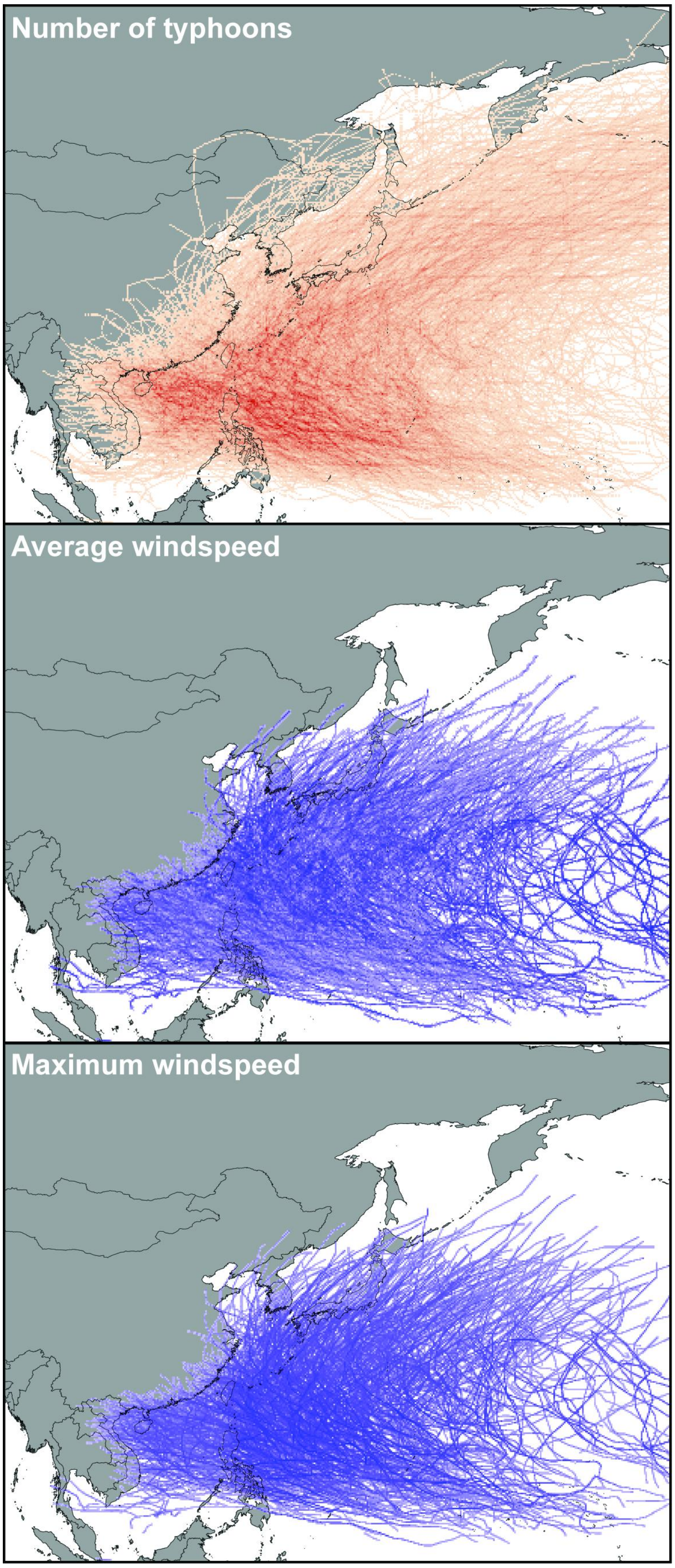

Figure 3 Three views of gridded data summarizing typhoon frequency and intensity across the Western Pacific north of the Equator

Notes: Gray (on land) and white (at sea) indicates a zero value. Color ramps indicate values ranging from low (light) to high (dark).

Table 1 Summary of data dimensions, dataset names, and time spans regarding typhoon frequency and intensity in the Western Pacific Ocean north of the Equator, during 1951 – 2014

Variable	Dataset	Time span
Number of typhoons	Typhoons_count_all	1951 – 2014
	Typhoons_count_post2000	2000 – 2014
	Typhoons_count_pre1980	1951 – 1979
Average windspeed	Typhoons_avgwind_all	1977 – 2014
	Typhoons_avgwind_post2000	2000 – 2014
Maximum windspeed	Typhoons_maxwind_all	1977 – 2014
	Typhoons_maxwind_post2000	2000 – 2014

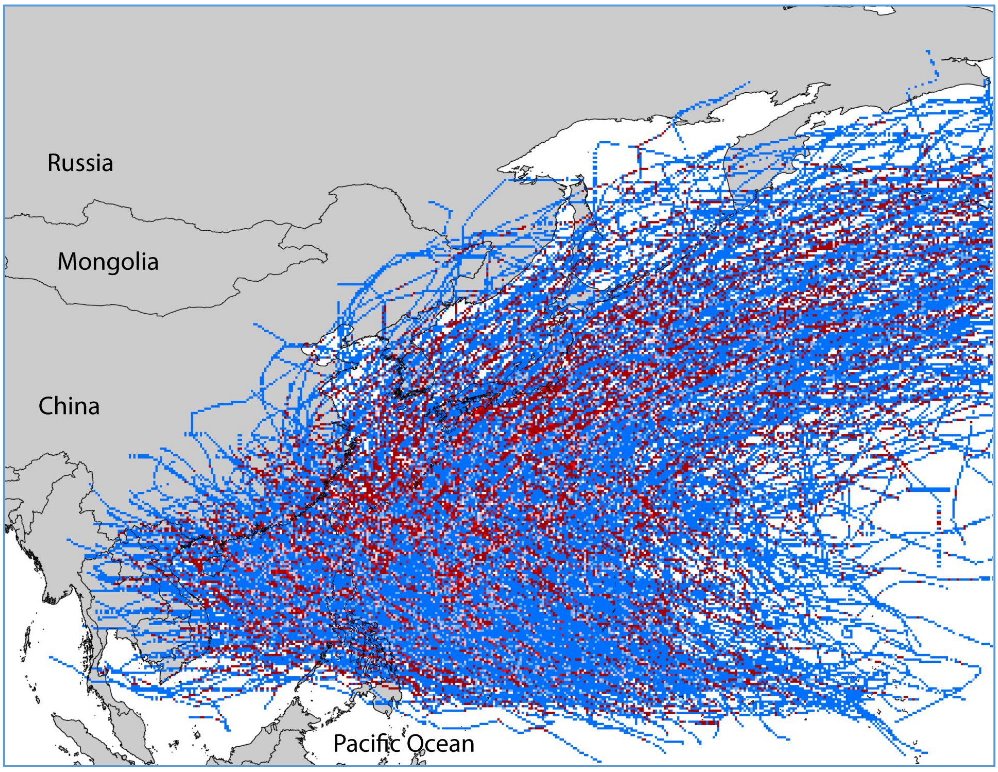

Figure 4 Summary of changes in typhoon frequency between 1951 – 1980 and 2000 – 2014

Notes: Dark blue = 50 – 100% reduction, light blue = 1 – 50% reduction, gray = no change, light red = 1 – 25% increase in frequency, medium red = 25 – 50% increase, and dark red = >50% increase in frequency. Windspeed comparisons between these time periods were complicated by limited availability of windspeed data for the early time period.

2.2 Methods

Individual typhoon tracks were supplied by the Japan Meteorological Center in the form of ASCII, column-delimited files that summarize daily position, time, strength, etc., for each typhoon (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/trackarchives.html). Although it is easy to turn these files into GIS shapefiles, the line-format shapefile format does not permit lines to have different attributes at different points along their extents. As such, we created shapefiles that connect the consecutive points along the track of each typhoon, but that represent sets of objects within the shapefile, each centered on a point and connecting the midpoint of the line segment to the previous point to the midpoint of the line segment to the next point. Figure 1 summarizes the methodology by which these data were created; code in R[12] is provided at http://hdl.handle.net/1808/22465. Individual typhoon shapefiles were merged to form a single shapefile including the tracks of all 1673 typhoons.

To convert the line-format typhoon tracks to a raster-format view of the region, we created a polygon-format, "fishnet" shapefile that consisted of square polygon elements that were 0.1° (~11 km) on each side. We used spatial joining procedures in ArcGIS 10.3 to attach fishnet identification codes to typhoon segments. From this intermediate product, we were able to create tables summarizing counts of typhoons, and averages of average and maximum wind speeds (note that wind speed data were available only for 1977 to present, apparently because those data were not available previous to that year) for each polygon in the fishnet. Finally, the fishnet was converted to raster format, and resampled (cubic convolution) to 0.2° to generalize the results somewhat (further resampling may be advisable, to remove some spatial artifacts related to reporting of integer values for typhoon positions).

3. Sample description

The overall pattern of frequency of typhoons across the Western Pacific north of the Equator shows some fascinating patterns and nonlinearities (Figure 3). The broad-scale limitation of Western Pacific typhoons to approximately 7 – 53°N latitude was clear among our results, but even more striking was a clear concentration in terms of typhoon frequency at latitudes of 7 – 19°N. This concentration was not noticeable in terms of typhoon strength (Figure 3). The data were synthesized into four products, presented in this contribution: (1) a line shapefile summarizing 1673 typhoon tracks, and GeoTIFF raster files summarizing (2) the average value of windspeed, (3) maximum value of windspeed, and (4) number of typhoons across the Western Pacific north of the Equator. These summaries were developed – as feasible – for the entire time period of the data, and for before 1980 and after 2000; the latter two time periods were in response to the timing of major global temperature increases.

4. Quality control and assessment

Data quality assurance checking involved detailed inspection and exploration of patterns to detect any typographical or other data errors. The data provided herein were re-processed from the original data supplied by the Japan Meteorological Center, and as such depend on the quality and reliability of the original source data. We noted some level of "striping" that coincided with integer values of latitude and longitude, which appears to reflect coarse-resolution reporting of typhoon positions (e.g., to the nearest integer degree). This problem was ameliorated by resampling to 0.2° (~22 km) resolution, but is still present; users concerned about these effects may wish to resample to still-coarser resolutions.

5. Value and significance

This dataset is, to our knowledge, the only synthesis of raw typhoon data into openly accessible, digital datasets. As such, this dataset is the first and only existing summary of broad, long-term patterns in typhoon frequency and strength across a major ocean basin, for use in diverse applications to questions in other fields. That is, several typhoon track datasets are available online, including the Japan Meteorological Agency (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/trackarchives.html), Joint Typhoon Warning Center (https://metoc.ndbc.noaa.gov/web/guest/jtwc/best_tracks), and others. However, those data exist as series of coordinates and intensities only, and not in any summary form. As such, our shapefile compilation and GeoTIFF raster summaries appear to be unique, and summarize important dimensions of environmental conditions and disturbance.

6. Usage notes

Code for processing point-format data from the Japan Meteorological Center into shapefiles is available at http://hdl.handle.net/1808/22465. The actual data are available at http://hdl.handle.net/1808/22466. These data and code packets are housed in KU Scholarworks, a permanent digital repository providing open, global access to scholarly products of the faculty of the University of Kansas. There are no copyright or proprietary restrictions for these datasets.

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Data citation

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Authors and contributions

A. Townsend Peterson, PhD, Professor; research area: biodiversity, biogeography, ecology. Contribution: motivation of study, data analysis, writing.

Lindsay P. Campbell, PhD, Post-doctoral Researcher; research area: disease ecology, landscape effects. Contribution: data analysis.

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